Stimulating Innovation in Inland Waterway Navigation – The 'Ecorace-Challenge' Project

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ABSTRACT

Inland Waterway Navigation (IWN) is often assumed to be non-sustainable and outdated. However, after taking a more profound look, this assumption appears to be not entirely correct. Compared to other transportation modes, IWN has generally better scores in terms of environmental friendliness and sustainability. In addition, there is still sufficient spare capacity on most of the waterways. However, by developing more energy efficient drivetrains, improvements can still be made in terms of CO2, NOx, and especially Particulate Matter, the weaknesses of the currently used drive trains. Therefore, and in order to promote IWN, the student-competition 'Ecorace-Challenge' was launched. The aim of this competition is to stimulate technical innovation in the sector, and to make students aware of the opportunities IWN offers. As such, this project, in close collaboration with industry, was devised with the aim to improve the interaction between young engineers and the IWN-sector and to let them help shaping the future of IWN. The first edition of the 'Ecorace-Challenge' was held on May 9-11 2014 on the channel 'Ieper-Ijzer' in Belgium. Within the competition, each team had to build its own vessel with an efficient and sustainable drivetrain (e.g. electrical, hybrid etc.), and making use of innovative materials. Moreover, the vessel should be scalable to the smallest type of ships that is currently being used for IWN to transport cargo. In addition, they needed to make a business plan, sell their creative and innovative ideas to investors, and a FMEA. Collaboration of the teams with different industrial sectors was crucial here, and proved to be very successful. In this paper, the full concept of the 'Ecorace-Challenge' competition, as well as how it contributes to future innovative developments in IWN, is described. The next edition will take place in May 2015, and is open for international teams.

Keywords: Ecorace-Challenge, Engineering Education, Inland Waterway Navigation, Innovation, Sustainability

1. INTRODUCTION

The transport industry is the backbone of the European economy. It accounts for about 7% of the GDP and more than 5% of total employment in the EU can be retrieved in land transport (road, rail, inland waterways and pipelines), sea transport and air transport (European Commission, 2009). Hence, the biggest challenge in this increasing globalized, complex and demanding world is to create sustainability and environmental friendliness in this transport sector. Various problems pop up like environmental effects, continuing urbanization of Europe's population, stringent emission regulations, projected increase in both passenger and freight traffic in the coming years, the depletion of energy resources, etc. (Bhoomkar and Ceuppens, 2013). Europe's logistic sector has to evolve to a more resource efficient economy and more R&D and innovation (in alternative fuels, green vehicles, noise reduction, etc.) is necessary to create sustainability in the transport and logistic sector.

The European inland waterway network contains more than 42.000 km of rivers and canals and is very important in following countries: Benelux, Germany, France, Austria and Hungary. Flanders in Belgium has one of the most dense networks in the world. Rivers and canals extend for 1375 km, of which 1076 km are used for professional navigation. Moreover, according to recent studies, there is a considerable reserve capacity on the waterways, which is not the case for road and railway transport (Macharis, C., van Lier, T., Pekin, E. en Verbeke, A.; 2011). Despite the opportunities inland waterway transport offers, it still struggles with some contemporary issues to obtain a modal shift. It has a dated infrastructure, polluting vessels, as well as an outdated image. Improvements in terms of environmental friendliness and sustainability are essential for inland waterway transport, especially concerning the emissions of particulate matter and nitric oxide (Macharis, C., van Lier, T., Pekin, E. en Verbeke, A.; 2011). Nevertheless, Flanders takes actions to stimulate and encourage people and industry to reinvent the waterways in a sustainable way and tries to demonstrate its environmentally friendly aspects in the logistics and transportation sector. This is done by launching several initiatives where organizations work together on different aspects of inland navigation. An example of these initiatives is 'Water-Truck', where the aim is to further develop and optimize cargo transport using small inland waterways by introducing a new navigational concept, consisting of a pusher and adapted pushed barges (see Fig. 2). Another example is 'Distrivaart', which is a multimodal (combination of road and inland waterway transport) and innovative concept for the transportation of pallets.

Fig. 1 Inland waterway navigation at the Port of Antwerp in Belgium

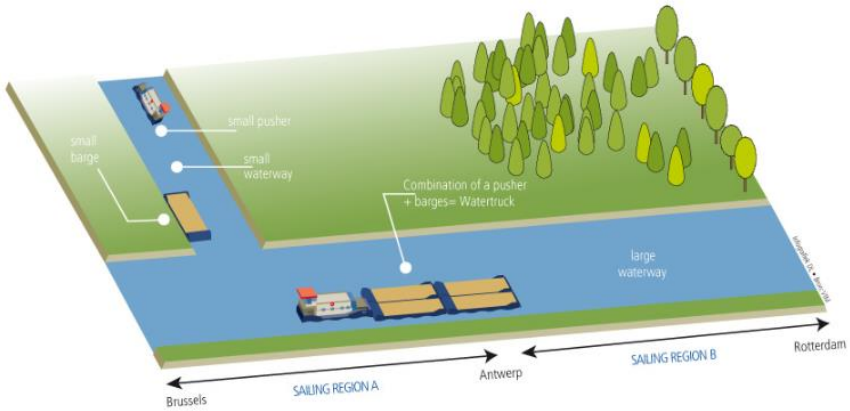

Fig. 2 Water-Truck

Also in the field of education, Flanders is stimulating awareness about inland waterways. KU Leuven - GROUP T and Waterwegen en Zeekanaal NV and NV De Scheepvaart, two administrators of the Flemish waterways, have developed a competition for technical students focusing on vessels for the inland waterways. In the 'Ecorace-Challenge', teams of technical students from different universities are being challenged to build a 6 meter long vessel, which represents a scale model of a typical inland waterway vessel. The primary focus is on developing an alternative drivetrain which propels the vessel more efficient and sustainable than current practices and also on making use of innovative materials. During the design phase, they need to take into account strict regulations which are imposed by the organization of the competition. An important objective of the 'Ecorace-Challenge' is to bring students and maritime industry closer together. Therefore, during the year prior to the competition, the teams are invited to attend several seminars where they are introduced to the sector and its companies. Within these seminars students gain insight in how navigable waterways can be complementary to road or railway transport in order to obtain multi-modal transport. At the end of each of these seminars, students and professionals can interact during a networking event. What is more, the 'Ecorace-Challenge' also wants to encourage entrepreneurship and innovation within this sector. Therefore, the teams need to write a business plan to elaborate on the possible scalability of their project to the industry. Herein the knowledge and expertise gained during the seminars and meetings with professionals can definitely be used.

During the weekend of the competition, the self-designed vessels are inspected to check compliance with the regulations. In parallel, the sustainable and innovative aspects of each design are inspected and assessed based on level of difficulty, progression and innovation. Because the technical regulations of the competition allow a wide variety of energy sources, vessels using hydrogen (fuel cell or combustion), bio-fuels or solar energy can be expected. Next, during the navigation challenges in different disciplines, several aspects of the vessel are investigated and scored, like speed, manoeuvring with a load of 1 ton and passing through a lock.

The goal of this challenging project is to make people (especially students) aware of the opportunities and importance of this transport mode and to show that the inland waterway sector is much more than the old-fashioned character. Based on the first edition of the 'Ecorace-Challenge', a boat competition for technical students in terms of sustainability and environmental friendliness, it can be concluded that this is a good project to make (young) people aware of the transport mode of the future: inland waterway transport (youtube aftermovie: https://www.youtube.com/watch?v=DWQYvsui1-o).

2. IWN, AN INTERESTING AND SUSTAINABLE INDUSTRY

Inland waterways still play an important role in nowadays transport sector, especially in western Europe where a dense network of waterways can be found (see Fig. 2). The Belgian waterway network is regionalized and is hereby divided into the following categories: the Flemish Region, the Walloon Region, the Brussels Capital Region and the maritime accesses. In the Flemish Region, the waterway network is managed by two waterway managers: "Waterwegen en Zeekanaal NV" and "NV De scheepvaart". "Waterwegen en Zeekanaal NV" manages the central and western part of the Flemish waterway network. "NV De Scheepvaart" manages the most important waterways in the

province of Antwerp and Limburg. The Belgian waterway network is an important passage to waterways in other West-European countries like The Netherlands, Germany, France, Luxembourg, Austria and Hungary. Besides, the port of Antwerp is the second largest port of Europe and has an interesting strategic location, right in the middle of crossroads of major European trade routes.

Fig. 3 Maps of the inland waterway network in Europe and the world

This dense network in Flanders can reach deep into the inland. It is therefore logical that the combination of water and road or rail transport has strong assets. Sea and inland waterway transport in combination with modal shift will be the transport mode of the future and will play an important role in reducing the pressure on the roads in the future (Macharis, C., van Lier, T., Pekin, E. en Verbeke, A.; 2011).

Water transportation is one of the oldest ways of transport. In a large part of Europe and Belgium there is ample availability of waterways and transportation can be done throughout the year. Water transport can be done via rivers, canals and sea which are the natural ways, cost efficient, safe and environmental friendly (Macharis, C., van Lier,

T., Pekin, E. en Verbeke, A.; 2011). Therefore, it can be concluded that this transport mode has a lot of potential compared to other modes of transportation.

The use of ships is very sustainable and environmentally friendly compared to road, air and rail transport (Macharis, C., van Lier, T., Pekin, E. en Verbeke, A.; 2011). The energy consumed to cover a certain distance is much more efficient. For example, a ship of 1350 tons consumes four to seven times less fuel per kilometre than trucks. Moreover, with 5 litres of fuel a ship can transport 500 ton of goods for 1 km, whereas a train can only travel 333 tonkm, a truck only 100 tonkm and an airplane hardly 6 tonkm (see Fig. 4) (Promotie Binnenvaart Vlaanderen, 2008). This benefit includes also less polluting emissions into the air. Furthermore, a long-term trend is the decline in the number of inland ships, accompanied by an increase in the load capacity which make the waterways even more attractive.

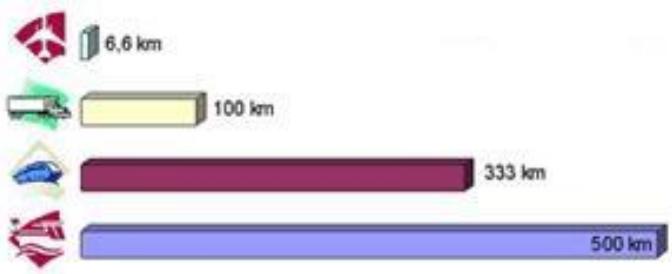

Fig. 4 Number of ton kilometres per transport mode with 5 litres of fuel

2.1. Challenges for Flanders inland waterways

Improvements in terms of environmental friendliness and sustainability can still be made for inland waterway transport, especially the emissions of particular matter and nitric oxide. The lifetime of a cargo ship can easily reach over 20 years. In many cases the type of drive train has been kept original, but technologies has improved and nowadays available technologies are more efficient and cleaner. The EU already announced some measures and regulations to reduce the emissions of nitric oxide by 2020 (Macharis, C., van Lier, T., Pekin, E. en Verbeke, A.; 2011). Therefore R&D and innovation in the inland waterways sector has to be encouraged.

Moreover, as a result of the outdated image and infrastructure of this business, people don't see the opportunities and benefits. Today as never before there is a growing need for integrating environmentally sound choices into supply-chain management research and practice (Cucchiella et al, 2010). It's not only an interesting, economic and environmental way of transport but it can also be an interesting alternative to release the pressure on our highways when we manage to combine water, rail and road transport. Therefore people (and especially students, the policymakers of the future) need to be made aware of the need of sustainability and environmental friendliness in the logistics and transport sector.

3. THE ECORACE-CHALLENGE

To encourage young people to interact with the businesses around inland waterway transport, NV De Scheepvaart, Waterwegen en Zeekanaal NV and KU Leuven - GROUP T launched a new competition for technical bachelor and master students. The aim of the "Ecorace-Challenge" is to strengthen the interaction between Education,

Research and Industry and to stimulate the business climate within the sector, so new developments and initiatives can be launched (see Table 1).

Partners involved (based on sector)	**Companies**
Inland waterway management	Heyrman de Roeck, Futureship a GL company, …
Logistics	ODTH, Van Moer Stevedoring, Eriks, …
Local governments	Province of Flemish Brabant, Vredesstad Ieper, Promotie Binnenvaart Vlaanderen, Ecowerf, …
Finance and banking	BNP Paribas Fortis, …
Batteries and energy storage	Battery shop, Farnell, Stroomwinkel, EnerSys, …
Composites engineering and manufacturing	Acrosoma, MC Technics, Fibers Included, …
Drive engineering	Umicore, Torqeedo, …
Engineering management	Artes, Soetaert, MBG, Besix, Multi Projectexperts, …

Table 1 Partners involved in the Ecorace-Challenge project

The teams are challenged to start their own business as ship builders. They have to design and build a small vessel, making use of sustainable technologies and innovative materials. Moreover, the vessel should be scalable to the smallest type of ship that is currently being used for inland waterway navigation. For the realization of their vessel, the teams need to gain their own financial and material recourses.

During the project time, teams need to brief periodically the organization about their progress. There are also some deadlines related to design reports, an electrical wiring diagram, a FMEA (Failure Mode and Effects Analysis) study and a business plan.

Moreover, teams are also invited to different networking events by companies and organisations within the sector. Consequentially students can hopefully benefit from their new contacts and insights in the sector. Occasionally they will be asked on events to talk about their experience with the Ecorace-Challenge and their progression. At the end of the competition they need to present their business plan to a jury of professionals active in the inland waterway sector and/or research institutes. It is of big importance that teams use the information and the insights of the network events for their defence.

The business plan involves a 30-minute formal presentation to a jury of experts (imaginary investors) followed by 15 minutes of questions, with a view to obtaining a business deal to manufacture and sell the team's (upscaled) vessel. The judges will assess the business plan on the basis that they have a developed scaled prototype vessel, but also a well-developed business case and project plan

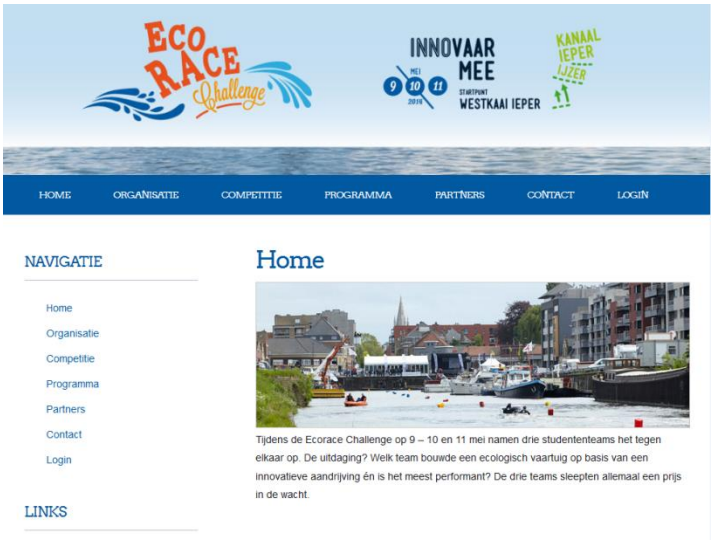

Fig. 5 Website of the Ecorace-Challenge (www.ecorace-challenge.be)

3.1. Teams

From 9 till 11 May 2014, the first 'Ecorace-Challenge' was held on the canal 'Ieper-Ijzer' in Belgium. The organizing committee opted to only allow a small amount of teams to participate within the pilot edition of this competition. Because the competition is funded through Flanders industry, only Flemish Universities where able to apply to the event. The first edition of the 'Ecorace-Challenge' hosted four universities which competed against each other: University of Antwerp, Hasselt University, KU Leuven – GROUP T and Antwerp Maritime Academy (see Fig. 6). The event took place at the marina nearby the lovely city of Ieper. The next edition will take place in May 2015 on the canal to Beverlo in Leopoldsburg in Belgium, and will definitely be open for international teams.

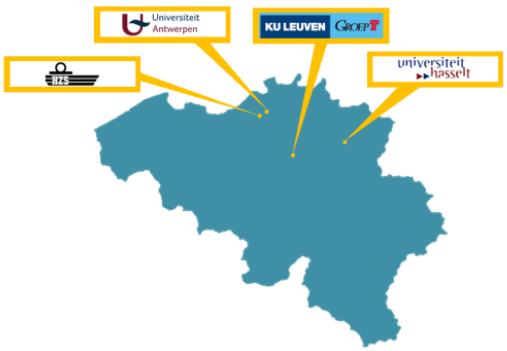

Fig. 6 Map of Belgium showing the participating Universities

3.2. Technical regulations

Within the technical side of the competition, each team builds a vessel capable of sailing more than 30 km. They start from line diagrams of a barge which is scaled down to a boat with a length of 6 m. The teams are free to produce their own hull in any material. They can opt for standard glass-fibre composite solutions or look for more sustainable options like for example bio-composites. Before the teams are allowed to sail the vessel during the competition all teams need to indicate by calculation that the

hull is strong enough. This matter is very important when you know there will always be one or two persons on board with the possibility of an additional load of one ton. Moreover, the vessel will be inspected in detail by the judges during the official scrutineering.

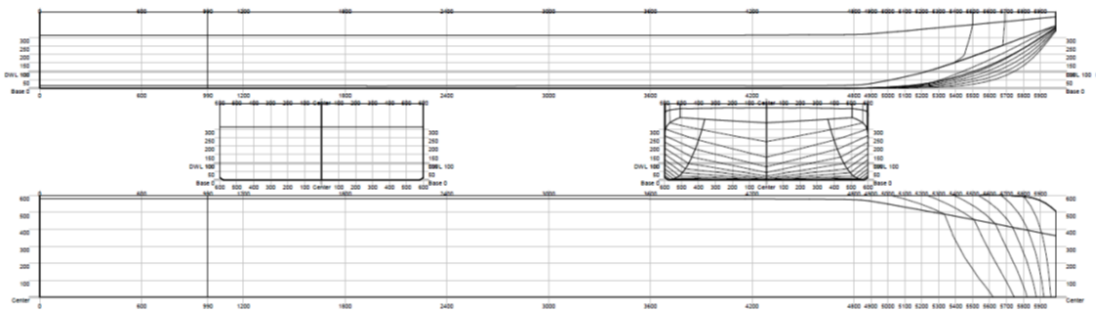

Fig 7 Line diagram of a barge imposed by the technical regulations

To inform all teams of the different technical restrictions a document of about 20 pages was written. The main purpose of this document is to assure that all vessels comply with a high standard of safety. Besides, it also allows a fair competition between the teams.

The design rules for the propulsion system are relatively open, but green design is encouraged, since it is an important sub-topic to sustainable transportation and environmental awareness (Srivastava, 2007). The regulations allow different types of fuels, going from solar panels, hydrogen, CNG, petrol to bio-fuels. Only wind, human and animal power are not allowed. This can be used for direct propulsion or for on-board energy generation which may be stored in an energy storage system of maximum 5 kWh.

Fig. 8 Hull of the vessel of the KU Leuven – GROUP T team and the University of Antwerp

Teams are only allowed to make some design changes within the last meter of the 6 meter long hull to optimize their propulsion system. The standard hull speed is determined at about 12 km/h, but can still be improved. The maximum allowed output power for the propulsion system is 8 kW or 6 hp. The topology of propellers is open, so one or more propellers are allowed to improve manoeuvrability. Teams need to take into account the scalability of their drive train, so it is more or less possible to apply the same system in an up-scaled barge. This will be of importance for the decisiveness of their business plan.

3.3. Overall regulations

The competition doesn't consist of only one race. Multiple challenges are defined to make sure the boats can be used in versatile situations, so it is agile, sustainable, fast and reliable.

Additional to the challenges, a more management-oriented part is introduced in the project by the writing and the presentation of a business plan. Each challenge and assignment will be scored separately with points. At the end, the team with the highest overall score will be awarded as the overall winner of the "Ecorace-Challenge". The scoring of the different challenges and assignments can be found in table 2.

Category	Max. points
Design report	100
FMEA	50
Electrical scheme report	100
Sprint	50
Forward-stop-backward	50
Slalom	50
Endurance	300
Business plan and presentation	100
TOTAL	**800**

Table 2: Scoring overview of assignments and challenges

3.4. Jury

A team of professionals experts was formed to judge the different challenges of the teams during the first edition of the 'Ecorace-Challenge'. To maintain the objectivity of the judging, there was decided to create a different jury group per day with different kind of expertises according to the challenges. A good mix of academic experts and professionals of the industry was necessary in order to form a strong and interesting jury group. The next edition will take place in May 2015, and is open for an international jury group.

3.5. Challenges

The competition exist out of four different practical tests on the water: Sprint, Forward-Stop-Backward, Slalom and Endurance, whereby each team tries to set a best time for each challenge. For the Sprint, Forward-Stop-Backward and Slalom challenges speed is mainly important, while energy efficiency plays an important role in the Endurance challenge. The winning team gains the maximum point of the challenge where the points of the other teams are calculated by a formula taking into account the time difference with the fastest team.

3.5.1. Sprint

Within this challenge, teams need to cover a distance of 200 meters as quick as possible, starting from standstill. Teams may change propellers if needed. The goal is to accelerate as quick as possible.

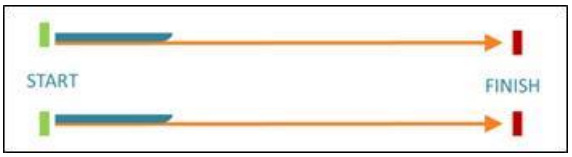

Fig. 9 Illustration of the Sprint Challenge

3.5.2. Forward-Stop-Backward

Having a good manoeuvrable ship for inland waterway navigation is essential. During the challenge the shipper need to sail 100 meters where after he tries to come to a standstill in a marked area. Next, he will need to navigate 100 meters backward. This challenge will be scored on time, but as well by a jury on its smoothness.

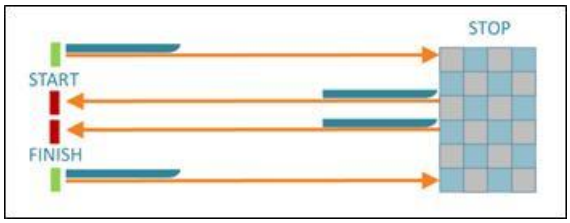

Fig. 10 Illustration of the Forward-Stop-Backward Challenge

3.5.3. Slalom

For the Slalom challenge the vessel needs to follow a track, indicated by buoys, of 500 meters. This test will show how stable and agile the ship is. This challenge will be scored similar to the Forward-Stop-Backward.

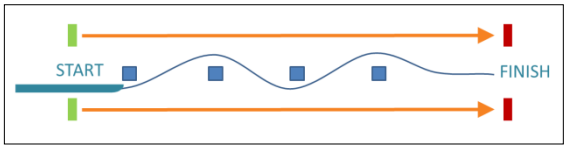

Fig. 11 Illustration of the Slalom Challenge

3.5.4. Endurance

The flagship of all the challenges is the Endurance: a 18 km long trajectory on the Ieperlee canal in Flanders. During this part of the competition teams will pass a lock on their way two times. The first half of the trajectory, teams will sail without any ballast. The second half, teams need to take an extra ballast of a ton on board of the vessel, as shown in figure 13 below. Vessels on solar energy don't need to take an extra ballast of a ton, because this will not be feasible for them. This adjustment will be inserted in the key formula to calculate the points for this challenge.

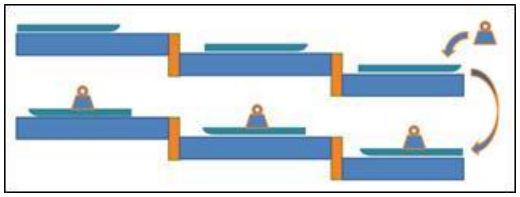

Fig. 12 Illustration of the Endurance Challenge

Fig. 13 KU Leuven – GROUP T vessel with a load of 1 ton of sand

In contrast to the other challenges, not only time will be taken into account but also efficiency. Each vessel power consumption will be monitored. The key formula will take both parameters into account to determine the points gained during this challenge.

Fig. 14 Relation efficiency vs speed

3.5.5. Award ceremony

At the end of the competition there were 3 different awards. A 1st for the overall winner, i.e. the team with the highest total score. A 2nd for the team with the most efficient vessel, i.e. the team that completed the Endurance test in the most efficient way. A 3rd for the team with the most innovative vessel, i.e. the team that most excels in the use of new sustainable technologies.

Fig. 15 KU Leuven – GROUP T with the most innovative vessel award

4. CONCLUSION

As result of the dense network of rivers and canals in Flanders, inland waterway transport still has a lot of potential to grow. Unfortunately, throughout the years the image of the sector has become outdated and less attractive. Now it is the time to reinvent the business and to show the public the potential and its benefits. Inland waterway transportation can be seen as an economical and sustainable alternative to road and rail transport.

Therefore this paper presented an interesting initiative "Ecorace-Challenge" to reduce the gap between Education, Research and the Inland Waterway Navigation, especially by young people. The initiative is a competition for bachelor and master students with interest in maritime industry. The Ecorace-Challenge covers both a technical side, where each team needs to build a 6 m long vessel with a sustainable drive train and innovative materials, and a more management-oriented side, where the team needs to act as real ship builders and present their business plan to a jury of experts. For the proper conduct of the competition, guidelines and regulations were defined which each team needs to comply with.

From 9 till 11 May 2014 all teams came together in Ieper where the challenges of the first Ecorace-Challenge took place. This public event was organised in close collaboration with lots of support of the maritime sectors and related companies and organisations. The next edition will take place in May 2015, and is open for international teams.

5. ACKNOWLEDGEMENT

We would like to thank all the partners involved with the "Ecorace-Challenge", for their participation and collaboration during the competition.

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